

## WEATHER NOTES

## THE PATH OF THE KANSAS-MISSOURI TORNADO OF MAY 20, 1957

## Introduction

May 20, 1957, was a day of many tornadoes in Kansas, Nebraska, Oklahoma, and Missouri. The most sensational and destructive of these was the Kansas-Missouri tornado, which took over 40 lives, injured about 200, and caused millions of dollars of property damage. The greatest concentration of destruction was in the suburban Kansas City, Mo., communities of Martin City, Hickman Mills, and Ruskin Heights, although destruction was continuous along the entire path of the tornado.

The study to follow is limited to features of the tornado as revealed by a survey of the damage path. The survey had the following objectives: (1) To ascertain path and path width; (2) to ascertain times of passage; (3) to note any unusual characteristics; (4) to obtain photographs; and (5) to interrogate witnesses. A preliminary survey was made by air, after which a more detailed ground survey was made.

## Path and Path Width

The path of the tornado was examined by "section-lining" the area through which it passed; i. e., all section-line roads in the area were traversed and positions of the path determined to the nearest  $\frac{1}{10}$  mile. Slant width of the path was measured along section-line roads and then corrected trigonometrically to yield actual path width normal to the direction of motion. The path was arbitrarily taken as that portion in which major destruction occurred; e. g., uprooted and broken trees, collapsed buildings, etc. It did not include fringe areas where damage was minor, or where only fallout of debris occurred.

The path of the tornado is shown in figure 1. The first contact with the ground was about 2 miles southwest of Williamsburg, Kans. From there it continued to a point about 2 miles northeast of Knobtown, Mo. The path was a single one except near Homewood, Kans., where a second path lay parallel to and north of the main path. Average direction of motion was  $59^\circ$  (approximately east-northeast), but with the direction varying from  $90^\circ$  (east) north of Peoria, Kans., to  $40^\circ$  (approximately northeast) near Martin City, Mo. Length of the main path was 71 statute miles. Length of a secondary path near Homewood, Kans., was about 7 miles. Width of path varied from less than  $\frac{1}{10}$  mile to  $\frac{4}{10}$  mile. Table 1 shows path widths at various portions of the path. The letters refer to portions of the path as indicated on the scale at the bottom of figure 1.

One might have expected considerable skipping of the tornado along the path. However, such was not the case. With one exception, destruction occurred along every section-line road crossed by the tornado.

TABLE 1.—Width of tornado along various portions of the path identified by letter in figure 1 (in miles)

A-----	0.1 to 0.2	G-----	0.3	M-----	0.2 to 0.3
B-----	0.2 to 0.4	H-----	0.2	N-----	0.3
C-----	0.3 to 0.4	I-----	0.3	O-----	0.2 to 0.3
D-----	0.1 to 0.2	J-----	0.3 to 0.4	P-----	0.3 to 0.4
E-----	0.1 or less	K-----	0.2 to 0.3	Q-----	0.2
F-----	0.1 to 0.2	L-----	0.1 to 0.2		

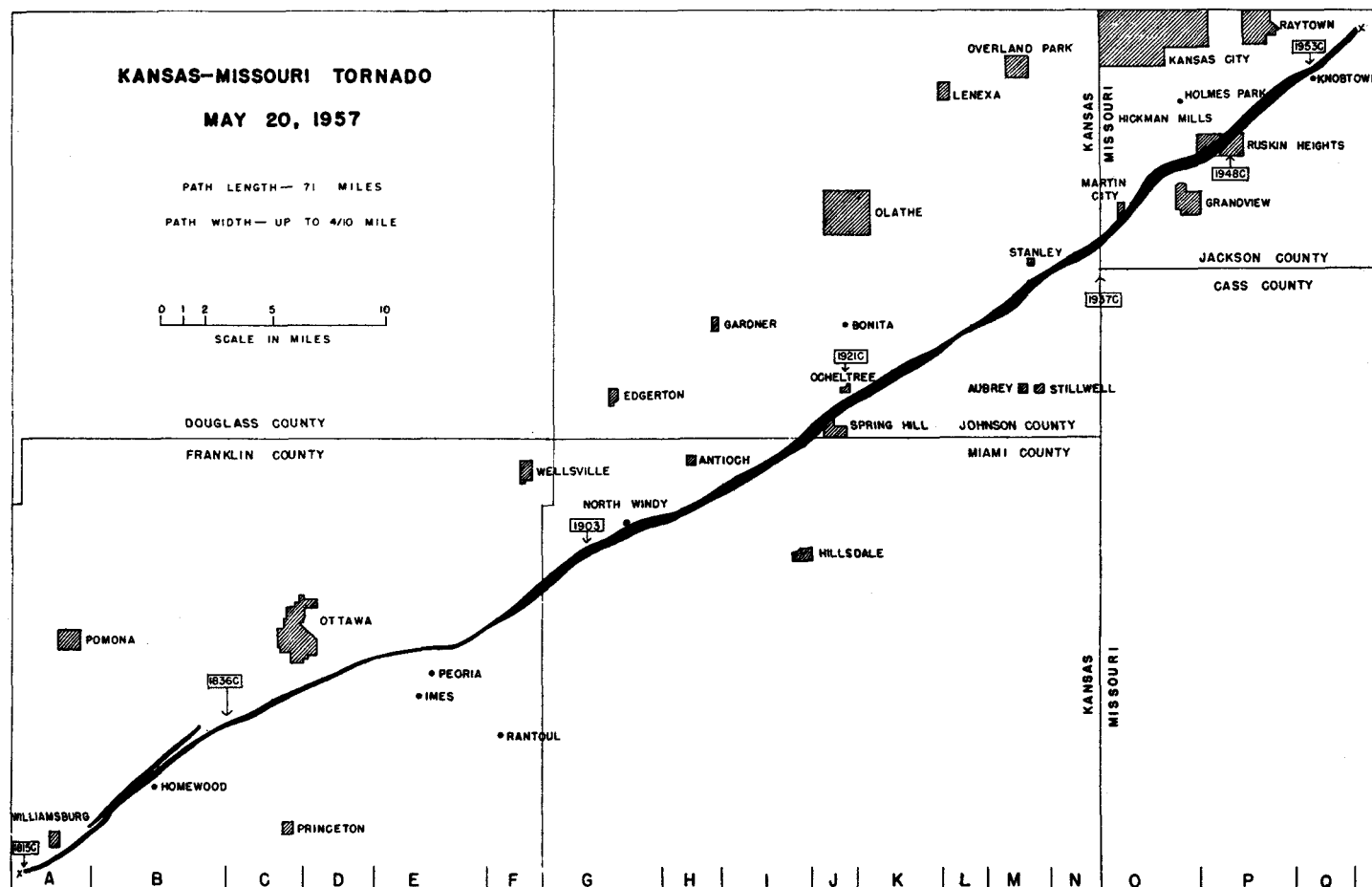


FIGURE 1.—Map of the tornado's path. Nearby cities, villages, and communities are shown. The lettered scale at the bottom of the map refers to remarks concerning path width given in table 1.

A check was made to determine if path width were related to topography. No such relationship was found. In some areas the path was wide in valleys and narrow on ridges. Elsewhere the reverse was true. There was no apparent tendency for the tornado to follow any topographic features; i. e., ridges, valleys, or rivers.

#### Times of Passage

Considerable difficulty was experienced in obtaining accurate times of the tornado's passage. Many witnesses were understandably preoccupied with self-preservation at the time, while many quoted the stoppage of electric clocks as the time of occurrence. Since the tornado caused a simultaneous power failure over a large area, the clocks in this area all stopped at the same time. The most reliable of the times have been entered in boxes in figure 1. They show that the tornado began at about 1815 CST and continued until shortly after 1953 CST for a total duration of a little more than 1 hour and 38 minutes. (The tornado continued for about 3 miles beyond the last time check of 1953 CST. Its exact time of dissipation was not ascertained.)

TABLE 2.—Speed of movement of the tornado for various time intervals. Speed was determined for only the first 68 miles of the 71-mile path

		m. p. h.
1815-1836 CST	12 miles in 21 minutes	34.3
1836-1903	18 miles in 27 minutes	40.0
1903-1921	13 miles in 18 minutes	43.3
1921-1953	25 miles in 32 minutes	46.9
Average	68 miles in 98 minutes	41.6

Accuracy of the speed of movement of the tornado is dependent upon the accuracy of the time reports, and can be taken only as a crude approximation for small portions of the path. Calculated speeds for various intervals are given in table 2. The table shows an apparent acceleration of the tornado; however, it must be realized that the time checks are not accurate enough to establish this definitely. For example, the time of first contact with the ground was variously reported in the range from 1815 to 1825 CST, sufficient to alter the initial speed given of 34.3 miles per hour.

#### Unusual Characteristics

**Funnels:** Evidence of multiple tornadoes was found in the Williamsburg-Homewood, Kans., area. A number of witnesses reported multiple funnels, with one witness claiming as many as six. Witnesses generally agreed that there was a massive main tornado with other smaller funnels in various stages of formation and dissipation surrounding it. The damage showed at least two paths of destruction in the Williamsburg-Homewood area, although the paths merged for a while into a broader path of destruction west of Homewood. The northernmost path could not be followed beyond the position shown in figure 1, and it is assumed that this tornado dissipated.

Multiple funnels were also reported in the Kansas City area. Some of the tree damage between Ruskin Heights and Knobtown appeared to support the existence of 1 or 2 additional funnels.

**Color:** From Williamsburg to Ottawa many witnesses stressed the fact that the funnel cloud appeared white in color. This may have been due to the fact that the setting sun to the west provided illumination to the funnel as it approached. Some witnesses reported seeing sunlight beyond the tornado. In the greater Kansas City area witnesses reported a heavy black cloud preceding a gray-white funnel.

**Precipitation, lightning, and noise:** In the Williamsburg-Ottawa area most witnesses reported only brief rain and a spattering of hail prior to the tornado with none during its passage. Reports of thunder and lightning varied, but many claimed that there was little if any in the tornado cloud itself.

A couple of witnesses reported warming before the tornado occurred; i. e., with the tornado at least a mile away.

The noise of the tornado was described by many witnesses. Generally it was perceptible about 5 minutes before the tornado struck. The sound was described as similar to many locomotives or many jet airplanes. The characteristic sound of the tornado appears to have been one of the most reliable precursors of its approach.

**Orientation of debris:** In the early portions of the path debris fell generally along the path. Later there was a distinct pattern of contrasting flow. This pattern was best observed at the North Windy crossroads (see fig. 1) where small trees in the right (southern) portion of the path fell in a direction of about 70°, which was along the path, and small trees in the left (northern) portion of the path fell in a direction of about 135°, which was into the path. The trees, typical of the small trees growing along section-line roads in eastern Kansas, showed a change in their direction of fall in a distance of less than 20 feet. The manner in which the trees fell could be interpreted as indicative of rotating motion or inflow motion. Coupled with the translational speed of the tornado, this information could with certain assumptions be used to compute the rotational and/or inflow speed of the tornado. These computations have not been made, but it may be pointed out that the orientation of debris suggests that translational velocity is of considerable importance.

**Fallout of debris:** In the greater Kansas City area there were numerous reports of small debris falling out over the city at a distance of 10 or more miles north of the tornado's path. Much of the debris consisted of small pieces of wood, corn husks, wheat straws, and occasional articles of clothing. This occurrence immediately suggested to the public that a second tornado had passed aloft over the main portion of the city. However, the debris is believed to have originated from the one tornado farther south for the following reasons: (1) The only source of debris was from the one tornado; (2) debris in the tornado was carried to great heights (a jet pilot flying at high altitude in the storm area observed debris rising to a height of 30,000 feet), and (3) winds at 30,000 feet (210°, 90 knots) were quite capable of carrying the debris to the north of the path during fallout.

**Dissipation:** It was not possible to follow a damage path of the tornado beyond a point

2 miles northeast of Knobtown, Mo. The funnel apparently dissipated by becoming longer and narrower with time before lifting into the cloud and dissipating. Before disappearing the portion in contact with the ground was described as having a whipping motion. One witness reported that the tornado broke up rapidly like a bursting balloon.

#### Summary

The Kansas-Missouri tornado had a path of considerable length and of considerable width. It was on the ground virtually all of the way during its 71-mile path. Only the fact that most of its path was over rural areas of Kansas prevented it from causing much greater death and destruction.

#### Acknowledgments

The authors are indebted to Mr. Roderick B. Cupp, manager of radio station KOFO, Ottawa, Kans., for valuable information and assistance; and to the many witnesses who were interrogated and who volunteered information by letter.—D. T. Williams and Howard H. Hanks, Jr., SELS Center, U. S. Weather Bureau, Kansas City, Mo.

### SOME RADAR ASPECTS OF THE MAY 20, 1957, KANSAS-MISSOURI TORNADO

The large thunderstorm cell with which the Kansas-Missouri tornado of May 20, 1957, was associated was tracked as a distinct echo by Topeka radar (WSR 3) from east of Wichita, Kans., to beyond Kansas City, Mo. By 1700 CST, while the storm was still well to the southwest of Emporia, Kans., it was evident from radar indications that this was a storm of unusual intensity. One aspect of the radar observations of this storm that may be worthy of note was the configuration of the vertical cross section of the echo as shown

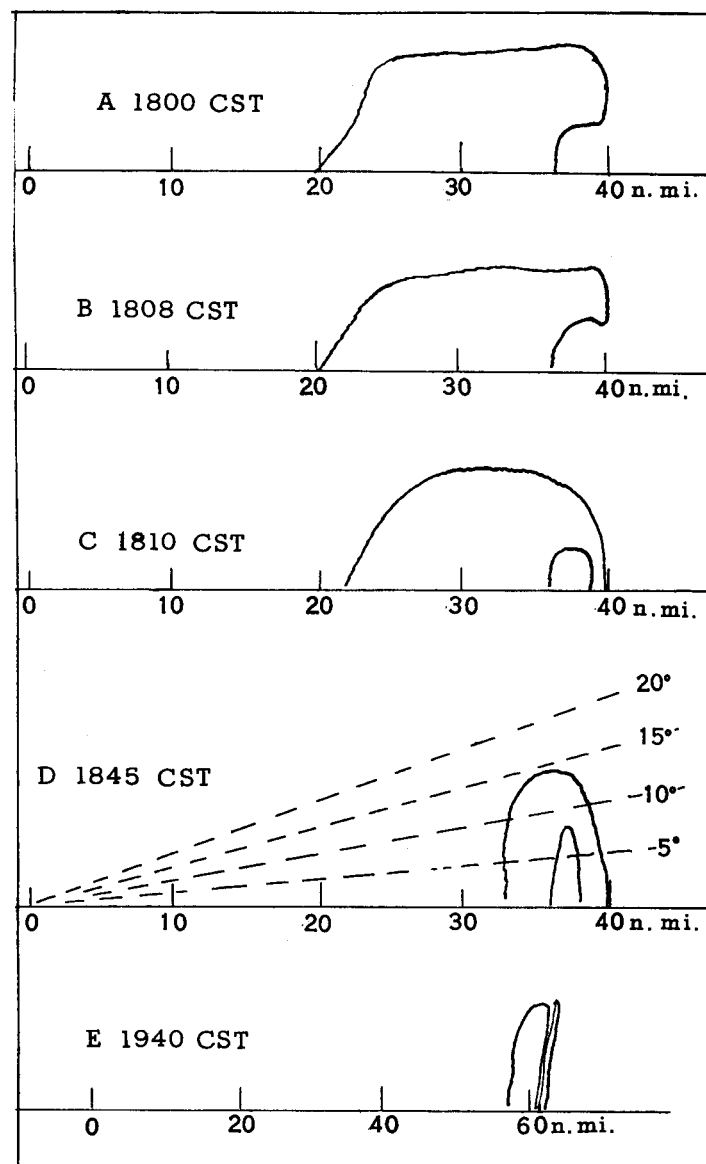


FIGURE 1.—RHI radar echoes of Kansas-Missouri tornado May 20, 1957, as observed at Topeka, Kans.

by the RHI (Range-Height Indicator) scope. By 1800 CST a pronounced anvil-shaped extension from the southern edge of the echo was noted. An appendage then developed at the outer end of the anvil and rather rapidly grew downward to the ground leaving an enclosed clear area between it and the main echo. The time and place where the appendage extended down to the ground as observed by radar were within a few minutes and a few miles of the beginning of the ground path of the tornado as determined by Williams and Hanks (see fig. 1 of their note on p. 205). Following development of the appendage the area of the main echo seemed to shrink in size, but the clear space between the main echo and the appendage was maintained for about 90 minutes.

The five sketches in figure 1 show the appearance of the anvil-shaped echo and the appendage during the time it was under observation. Sketch D is reproduced from a rough drawing made by the radar operator at 1845 CST at about the time the tornado was south of Ottawa, Kans. The other sketches were constructed from memory after the event, so times and details represented in them are only approximate. Photographs of the Topeka radarscope were not obtained.

Figure 1A shows the approximate shape and appearance of the anvil-shaped echo when it was first observed south of Topeka at about 1800 CST. The echo was roughly circular and about 20 nautical miles in diameter with the nearer edge 20 nautical miles from Topeka. The anvil or hammerhead configuration was maintained with little change for 5 to 8 minutes.

Figure 1B shows the approximate shape and size of the echo when the appendage was first observed. The time the appendage was first noted can be fixed as not later than 1810 CST and it was more likely about 1808 CST. The outer edge of the echo was located over Waverly, Kans., at that time. The appendage grew downward rapidly and the radar operator estimates it was about 2 minutes from the time the appendage was first noted until it appeared to reach the ground. The downward growth was rapid enough that it was readily apparent with each vertical sweep on the RHI scope.

Figure 1C shows the approximate configuration of the echo at the time the appendage appeared to reach the ground. The appendage was estimated to be  $1\frac{1}{2}$  miles wide and the clear area also  $1\frac{1}{2}$  miles wide, with the top of the clear area about 20,000 feet high. Using the 2-minute estimate for downward growth of the appendage gives an approximate time of 1810 CST for the sketch in figure 1C. This determination places the touchdown of the pendant 5 minutes earlier and some 4 or 5 miles southwest of the beginning of the ground path of the tornado 2 miles southwest of Williamsburg as determined by Williams and Hanks in the preceding note. When the radar was returned to PPI (Plan-Position Indicator) scanning at about this time, no out-of-the-ordinary configuration was noted although the operator had been fully expecting to observe the hook shape thought to be associated with tornadoes.

Figure 1D is based upon a rough sketch made at 1845 CST at approximately the time the tornado was south of Ottawa, Kans. In a telephone conversation, the Ottawa cooperative observer some 10 minutes after the time of this sketch reported he heard the tornado but had been unable to see the funnel because of heavy rain, although people in the southern part of Ottawa south of the heavy rain area had seen the funnel. The observer was approximately 3 miles north of the tornado track as determined by Williams and Hanks. By this time the overall size of the rain echo had noticeably decreased. The width of the clear space between the appendage and the main echo was still about  $1\frac{1}{2}$  miles, but the height of the clear space had risen from about 20,000 to 30,000 feet. Again the PPI presentation showed no indication of a hook in the tornado area, but a small and rather indefinite hook shape could be detected near the north edge of the main echo. It was at about this time that a pilot reported seeing two funnels touching the ground between Baldwin City and Ottawa. Baldwin City is 11 miles north-northeast of Ottawa.

Figure 1E is the approximate appearance of the RHI presentation at about 1940 CST when the tornado was near the Kansas-Missouri line. By this time the clear space between the appendage and the main echo was becoming indistinct but it was still detectable and appeared to have opened up all the way to the top of the echo.—Richard A. Garrett and Ralph T. Tice, Weather Bureau Airport Station, Topeka, Kans.

## WORLD RECORD LOW TEMPERATURE

SOUTH POLE, MAY 11, 1957

At 1445 GMT on May 11, 1957, there occurred at the Amundsen-Scott IGY Station (South Pole) the lowest temperature yet observed anywhere on the earth's surface,  $-100.4^{\circ}$  F. Table 1 presents the data at 12-hour intervals during the period May 9-11, with three additional observations on May 11. Included are date, time (GMT), surface

TABLE 1.—Meteorological data, Amundsen-Scott IGY Station (South Pole), May 9-11, 1957

Date	Time (GMT)	Pressure (mb.)	Wind		Temperature ( $^{\circ}$ F.)			
			Direction (meridian)	Speed (kt.)	Snow	Air		
						2 m.	5 m.	10 m.
May 9-----	0000	673.6	110E	11	-93.1	-90.5	-90.4	-88.8
Do-----	1200	674.1	90E	9	-96.6	-96.0	-96.0	-95.2
May 10-----	0000	672.6	70E	12	-99.5	-96.5	-96.8	-95.5
Do-----	1200	672.2	50E	11	-94.5	-92.5	-92.5	-91.9
May 11-----	0000	674.2	50E	13	-95.0	-92.8	-92.6	-91.1
Do-----	1200	673.3	40E	10	-99.0	-96.4	-93.9	-88.6
Do-----	1400	674.9	30E	6	-96.2	-91.5	-90.8	-88.8
Do-----	1445	-----	50E	4	-101.5	-100.4	-99.0	-92.0
Do-----	1800	674.9	30E	7	-85.2	-85.6	-85.1	-85.0

TABLE 2.—Mean and extreme temperatures, Amundsen-Scott IGY Station (South Pole), April, May, June, 1957

Month 1957	Mean wind		Temperature ( $^{\circ}$ F.)		
	Direction (meridian)	Speed (kt.)	Mean	Maximum	Minimum
April-----	20E	15	-69.7	-25.6	-89.1
May-----	30E	15	-68.3	-29.7	-100.4
June-----	40E	17	-69.5	-42.3	-97.1

pressure (mb.), surface wind direction according to the meridian along which the wind is blowing toward the Pole, windspeed in knots, snow surface temperature ( $^{\circ}$  F.), screen (air) temperature at 2 meters, air temperature at 5 m., and air temperature at 10 m.

The sharp temperature drop from 1400 to 1445 GMT at all levels occurred when the wind speed fell from 6 to 4 knots, and it seems related to a diminution in the vertical mixing of the air rather than to advection of colder air from elsewhere. The great rise in temperature from 1445 to 1800 GMT was associated with a slight increase in windspeed, but the significant factor seems to have been the increased radiation received from a layer of altostratus cloud which moved in to cover half the sky. This layer is estimated, from radiosonde data less than 3 hours previous to the time of appearance, to have had a temperature not lower than  $-72^{\circ}$  F. Ice crystals fell from a cloudless sky throughout the period until 1800 GMT on May 11, when the altostratus layer appeared, and rime ice or "snow down" was observed at 1200 GMT on May 8 on the snow surface and on windward surfaces. At this time the snow surface temperature was  $-87.4^{\circ}$  F., and the air temperature was  $-85.3^{\circ}$  F.

A "cold spell" with temperatures down to  $-95^{\circ}$  F. was experienced for several days prior to the record low temperature. The temperatures had been averaging about  $20^{\circ}$  F. warmer until then. In general, the surface windspeed has been stronger than first expected, but not strong enough to diminish the very strong surface temperature inversion averaging about  $50^{\circ}$  F. in the 25- to 30-mb. thick layer just above the snow surface.

As there has been much speculation about the temperatures expected at the South Pole (2,800 m. above m. s. l.), mean and extreme temperatures for the period April-June 1957 are given in table 2.

Further discussion on the aerology and micrometeorology of this event will be found in "Some Aspects of Antarctic Geophysics," by H. Wexler, to be published in a forthcoming issue of *Tellus*.—E. J. Flowers,\* Chief Meteorologist, Amundsen-Scott IGY Station.

\*Mr. Flowers, who submitted the information contained in this note, did not have an opportunity to check the final form of the manuscript.—Ed.